FINAL

**MARINE SHORELINE INVENTORY REPORT
WRIA 9**

Prepared for

Seattle Public Utilities

WRIA 9

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- Other:
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  - ➤ Marine shoreline inventory.apr an ArcView 3.2 project that includes many of the layers listed above including drift cell data with hyperlinked text files.

EXECUTIVE SUMMARY

This report presents a shoreline habitat inventory conducted for the Water Resources Inventory Area (WRIA) 9. The inventory area of WRIA 9 includes the marine shoreline of King County, Vashon and Maury Islands, and the entire shoreline of the City of Federal Way (Figure 1-1).

The project approach was based on mapping attributes of selected shoreline habitat features. Attributes were selected based on their relevance to nearshore habitat function for juvenile salmonids and the ability to classify their conditions using existing data sources or existing photographs. The attributes mapped were included 1) substrate, 2) marsh habitat, 3) aquaculture/shellfish harvest areas, 4) energy, 5) sedimentation (net shore drift), 6) freshwater inputs, 7) marine riparian vegetation (MRV), 8) large woody debris (LWD), 9) shoreline armoring, 10) impervious surfaces, 11) overwater structures (OWS) and marinas, 12) boat ramps, 13) jetties, breakwaters, and groins, and 14) marine rails. Some attributes were selected to be mapped based on existing geographic information system (GIS) datasets (attributes 1 through 6) and others were to be based on photo interpretation (attributes 7 through 14). Existing data for these attributes were compiled and assessed for spatial extent, resolution, scale, quality of information, and availability of metadata. The data compilation included gathering state agency reports and aerial photographs of the survey area. Attribute data were transferred to GIS for analysis and production of data layers.

Photo interpretation was completed using U.S. Geological Survey (USGS) 2002 Orthogonal Imagery (referred to as orthophotos) and Washington Department of Ecology (WDOE) 2000 aerial oblique photos. These photos were used separately or in combination to interpret attributes, considering photo quality and that some attributes were better interpreted by one source than the other. Early in the photo interpretation effort, a field verification survey was conducted to evaluate the data quality provided by photo interpretation. The field verification determined that the photo interpretation provided high confidence datasets for most of the attributes of interest; for those attributes that did not provide high confidence data based on the field verification, the photo interpretation methods were revised to improve data quality or clarify the definitions of what can be classified through photo interpretation. Spatial data from photo interpretation and field efforts were largely consistent with one another with no indication of major spatial inaccuracies. However, shoreline armoring was determined to be the attribute that would most significantly benefit from a larger-scale field verification effort.

This report provides the methods, results, and description of the GIS layers created for the marine shoreline inventory. A summary analysis of the inventory is provided, including total number of lineal shoreline miles surveyed and other parameters for selected attributes of interest. In addition, example figures are provided displaying typical spatial information from the GIS data layers. The GIS files produced during the data compilation and photo interpretation, including metadata, are provided on a compact disk (CD) accompanying this report.

1 INTRODUCTION

A marine shoreline habitat inventory was conducted for WRIA 9 to map a selected set of physical, biological, and anthropogenic shoreline conditions. Attributes were selected based on their relevance to nearshore habitat function for juvenile salmonids and the ability to classify their conditions using existing data sources or existing photos. This report presents the methods, results, and GIS products for the inventory. In addition, this report provides a summary analysis of inventoried conditions and features.

1.1 Inventory Area Description

In this document, the WRIA 9 inventory area includes the marine shoreline of King County, Vashon and Maury Islands, and the entire shoreline of the City of Federal Way (Figure 1-1). In Elliott By, the survey area included the north-facing shoreline of Harbor Island, but did not include any of the East and West Waterways or the Duwamish River. These areas were not included because they have been inventoried previously in other projects. The extent of the inventory includes the supratidal (above mean higher high water [MHHW]), intertidal (between mean lower low water [MLLW] and MHHW), and a portion of the subtidal (below MLLW) zones. Some features of the riparian corridor within 200 feet of the waterline were also characterized.

1.2 Approach

The project approach was based upon mapping attributes of selected shoreline habitat features relevant to nearshore habitat function for juvenile salmonids. Data were obtained through a compilation of existing GIS information and through photo interpretation. Some of the compiled datasets were refined to facilitate user access and interpretation. Early in the photo interpretation effort, a field verification survey was conducted to evaluate the data quality provided by photo interpretation. GIS data layers were produced with detailed information for the habitat attributes of interest

Figure 1-1   Vicinity Map

2 METHODS

GIS layers were produced by arranging existing GIS and photographic data from several data sources, in iterative steps, including compiling and refining existing information, interpreting GIS and photographic data, and field verifying photo interpretation results in certain areas.

Habitat attributes to be mapped were selected based on their contribution to nearshore habitat function for juvenile salmonids. Selected attributes included:

1. Substrate
2. Marsh habitat
3. Aquaculture/shellfish harvest areas
4. Energy
5. Sedimentation (i.e., net shore drift)
6. Freshwater inputs
7. Marine riparian vegetation (MRV)
8. Large woody debris (LWD)
9. Shoreline armoring
10. Impervious surfaces
11. Overwater structures (OWS) and marinas
12. Boat ramps
13. Jetties, breakwaters, and groins
14. Marine rails

Some attributes were mapped based on existing GIS datasets (attributes 1 through 6) and others were based on photo interpretation (attributes 7 through 14). Existing data for these attributes were compiled and assessed for spatial extent, resolution, scale, quality of information, and availability of metadata. The data compilation included gathering USGS 2002 orthophotos, WDOE 2000 aerial oblique photos, Washington Department of Natural Resources (WDNR) ShoreZone Inventory (ShoreZone) (2001), current Washington Department of Fish and Wildlife (WDFW) resource maps, and Washington Department of Health (WDOH) 2002 shellfish closure area information for the survey area. Refinement of this information included selecting the resolution and guidelines for mapping these attributes (Table 2-1). A data dictionary detailing all of the rules and definitions associated with the mapping effort is provided in Appendix A.

Table 2-1
Habitat Attributes and Classification System for Marine Shoreline Inventory

Habitat Attribute	Characteristic	Approach	Deliverable	Classification Definitions Used In Photo Interpretation
Substrate	Supratidal Intertidal Subtidal	Convert ShoreZone cross-shore tables into a series of line features to make substrate information more accessible. Lines created for supratidal (zone A), intertidal (zone B), and subtidal (zone C) to provide information on the dominant, subdominant, and tertiary substrate sizes. Information on substrate in zone components (i.e., A1, A2, and A3) combined to create one substrate classification for the zone.	Three separate shapefiles (one for each tidal zone) based on the ShoreZone shoreline and provide information from the ShoreZone cross-shore (XSHORE) tables. Each shapefile represents a different zone.	N/A
Marsh Habitat	Location	Line feature of compiled WDNR ShoreZone data on marsh vegetation distribution. Upland wetlands not mapped.	Compiled GIS data set of a line coverage of ShoreZone segments containing marsh vegetation.	Marsh Types (from ShoreZone) ▪ native high marsh (TRI) =*Triglochin, Salicornia, Distichylus*, and others in salt-tolerant assemblage ▪ sedges (SED) = brackish/freshwater wetland assemblages found at stream mouths ▪ dune grasses (GRA) = *Leymus mollis* and other salt-tolerant grasses ▪ *Salicornia* (SAL) = lower *Salicornia* marsh lacking other grasses/herbs
Aquaculture/ Shellfish Harvest Areas		Compile readily available information from WDFW (resource maps) and WDOH (shellfish closure areas 2002).	Compiled GIS data sets	N/A
Energy	Exposure Effective Fetch	Compile information from ShoreZone.	Compiled GIS data sets	N/A
Sediment	Drift Cells	Compile existing information from WDOE and link explanatory notations to the GIS line features.	A modified version of WDOE's (continuous coverage) Driftcell.shp that includes an additional field containing the explanatory notations.	N/A
Freshwater Inputs	Stream Locations Outfalls	Compile information from existing sources.	Compiled GIS data sets	N/A

Table 2-1
Habitat Attributes and Classification System for Marine Shoreline Inventory

Habitat Attribute	Characteristic	Approach	Deliverable	Classification Definitions Used In Photo Interpretation
Marine Riparian Vegetation	Location Type Distance Overhanging Density	Create GIS line feature to characterize MRV conditions within 200 feet of the water line using orthophotos and aerial oblique photos. Photo interpretation identifies MRV using classifications detailed in the far right column. Limited field verification examined how well the characteristics were determined using the existing photos.	One continuous shapefile based on the ShoreZone shoreline with the following attributes [Type] (tree, shrub, grass, other), [Distance] (adjacent, separated), [Overhanging] (yes, no, unknown), [Density] (continuous, patchy, unknown), [Description] (a summary of the above), and [Comments].	Type • Mature Trees • Immature Trees and Shrubs • Grass/Landscaped • None Distance • Adjacent = less than 10 meters from MHHW • Separated = greater than 10 meters from MHHW • Unknown Overhanging • Yes = overhanging intertidal zone by approximately 10 feet or more • No = not overhanging intertidal zone by approximately 10 feet or more • N/A Density • Continuous = the area within 200 feet of shoreline is 75 percent or more covered by vegetation • Patchy = the area within 200 feet of shoreline is less than 75 percent covered by vegetation • None = the area within 200 feet of shoreline has no vegetation Text Description • Combine Type, Distance, Overhanging, and Density (e.g., trees, adjacent, not overhanging, continuous) Comment

Table 2-1
Habitat Attributes and Classification System for Marine Shoreline Inventory

Habitat Attribute	Characteristic	Approach	Deliverable	Classification Definitions Used In Photo Interpretation
Large Woody Debris	Location	Create GIS line feature to characterize LWD accumulations and drift log accumulation areas using orthophotos and aerial oblique photos. Limited field verification examined how well the characteristics were determined using the existing photos.	One continuous shapefile based on the ShoreZone shoreline.	LWD Classifications • LWD = areas with more than 100 lineal feet of shoreline with downed trees across the intertidal zone • Drift Logs = areas greater than 100 lineal feet of shoreline with a continuous distribution of drift logs that includes a section with multiple logs stacked together in the intertidal zone or backshore • None = areas without LWD or Drift Logs present
Shoreline Armoring	Location	Use orthophotos and aerial oblique photos to modify the ShoreZone shoreline GIS line to differentiate whether the shoreline is armored or unarmored (at 50 linear foot resolution in City of Seattle and at 100 linear foot resolution in remainder of project area). Limited field verification examined how well the characteristics were determined using the existing photos.	One continuous shapefile based on the ShoreZone shoreline.	Shoreline Armoring Types • Armored • Unarmored
Impervious Surface within 200 feet	Location Amount	Create GIS line feature to characterize impervious surface conditions within 200 feet of the water line using orthophotos and aerial oblique photos. Photo interpretation identifies impervious surface using classifications detailed in the far right column. Limited field verification examined how well the characteristics were determined using the existing photos.	One continuous shapefile based on the ShoreZone shoreline describing the impervious surface coverage for 200 feet landward of MHHW. Resolution will be 200 linear feet parallel to MHHW.	Impervious Classifications • High = 75 to 100 percent impervious • Medium = 10 to 75 percent impervious • Low = less than 10 percent impervious Note: Houses/buildings, paved roads/paths considered impervious; yards/lawns and gravel areas considered pervious.

Table 2-1
Habitat Attributes and Classification System For Marine Shoreline Inventory

Habitat Attribute	Characteristic	Approach	Deliverable	Classification Definitions Used In Photo Interpretation
Overwater Structures	Type Compass Orientation Area	Create GIS polygon feature using orthophotos and aerial oblique photos to delineate overwater structures. Connected overwater structures delineated together in one polygon. This GIS feature provides accurate depiction of the outer extent of the structures, but will require estimation of the inside margin of the structure relative to the top of bank. Compass orientation or the primary waterward face of a structure and area (square feet) calculated and contained in the GIS attribute table. Marinas were delineated as the polygon of the overwater structure without boats.	A single discrete polygon shapefile delineating the attribute.	Overwater Structure Types ▪ Piers ▪ Marinas ▪ Docks ▪ Unknown Compass Orientation ▪ A number between 0 and 359, with 0 indicating north and 90 indicating east
Boat Ramps	Location Width Length	Create GIS polygon feature using orthophotos and aerial oblique photos to delineate boat ramps. The outer extent of boat ramps delineated as possible using the photos.	A single discrete polygon shapefile delineating the attribute.	N/A
Jetties, Breakwaters, and Groins	Location	Using orthophotos and aerial oblique photos, create GIS lines delineating jetties, breakwaters, and groins.	A single discrete line shapefile delineating the attribute.	Type ▪ Jetties ▪ Breakwaters ▪ Groins
Marine Rails	Location	Using orthophotos and aerial oblique photos, create GIS lines delineating jetties, breakwaters, and groins.	A single discrete line shapefile delineating the attribute.	N/A

2.1 Compilation of Existing Information

To begin compiling existing information, data were gathered from a variety of sources. The key sources of data used for the habitat inventory included existing GIS and photographic data, detailed in Appendix B. Following is a description of the types of information gathered for each attribute in the data compilation. More detailed information is contained in the data dictionary provided in Appendix A and complete metadata for these datasets are available on the accompanying CD.

2.1.1 Substrate

Two ShoreZone shapefiles were used to characterize substrate and cross-shore material in the survey area: the ShoreZone (sub_line.shp) shapefile, which contains general substrate information, and the ShoreZone cross-shore (xshrline.shp) shapefile, which details the materials comprising the cross-shore components of the tidal zones.

Substrate types in the ShoreZone sub_line.shp shapefile are characterized by category in the column titled SUBNAME. Categories include gravel; sand; rock; gravel and sand; rock, gravel, and sand; mud and fines; and man-made. With the exception of man-made, these categories are best described by the simplified Wentworth scale used in ShoreZone for substrate sizes, as follows:

- Gravels
    - Boulders – larger than 25 cm
    - Cobble – 6 to 25 cm
    - Pebble – 5 mm to 6 cm
    - Granule – 2 mm to 5 mm
- Sand - from very coarse to very fine; 0.5 mm to 2 mm
- Fines – from silt to clay; smaller than 0.5 mm

The xshrline.shp shapefile in ShoreZone provided information on the distribution of materials (substrates) in the supratidal (higher than MHHW), intertidal (between MHHW and MLLW), and subtidal (below MLLW) zones. This data source provided supratidal and intertidal material information for the entire project area; however, subtidal material information is provided for only a limited portion of the shoreline (less than 10 percent). It is unknown how representative this partial characterization is of

subtidal materials in the entire project area. In each zone, ShoreZone identifies discrete bands, called components, that have different materials than adjacent areas situated higher or lower in that zone. The supratidal and intertidal zones have one or more components identified in each ShoreZone unit, while subtidal zone information is available for only a small subset of the ShoreZone units in the project area.

Dominant cross-shore materials were characterized for each tidal zone using the following steps:

1. Determine the widest component widths for each ShoreZone unit within the tidal zone. For example, consider components 1, 2, 3, etc. in the supratidal zone; for ShoreZone unit X, if component 1 was 10 feet wide and zone component 2 was 20 feet wide, then component 2 would be the widest. In cases where two components had the same width, the zone component situated lower on the beach was used. This was deemed reasonable because the lower areas would be under water more often and therefore be accessible to fish for longer portions of each tidal cycle.

2. Determine the dominant material type in the widest zone component. For zone components with multiple material types, select the primary type using the explanation of the MATERIAL code in the ShoreZone Manual guidelines (available online at http://www2.wadnr.gov/nearshore/textfiles/pdf/szusermanual.pdf). Basically, this step entailed using only the substrate information before a semi-colon in the MATERIAL field. This step represents an interpretation of the ShoreZone data and no longer fully represents the ShoreZone characterization of the material.

3. Sort ShoreZone units by dominant material type and calculate the length of shoreline with each unique material type.

4. Determine which materials were dominant (i.e., occurred along the greatest length of shoreline in the project area), secondary (i.e., occurred along the second greatest length shoreline in the project area), and tertiary (i.e., occurred along the third greatest length shoreline in the project area).

5. Calculate percentage of total area characterized comprises the dominant, secondary, and tertiary material types.

2.1.2 Marsh Habitat

ShoreZone was used to provide a layer containing the extent of marsh habitats in the survey area by ShoreZone unit, including high and low marsh communities. The degree of patchiness of these marshes is included in this layer as noted in ShoreZone (TRI, GRA, SAL, and SED marsh groups in ShoreZone).

2.1.3 Aquaculture/Shellfish Areas

Information from WDOH was used to create the aquaculture and shellfish area layer. This layer contains information about commercial harvest areas and regulations.

2.1.4 Energy (Wave Exposure and Fetch)

ShoreZone was used to provide a layer containing wave exposure and effective fetch information for the survey area. Exposure is noted as the level of protection from waves and effective fetch is noted as increments of distance in miles.

2.1.5 Sedimentation (Net Shore Drift)

Data from WDOE, specifically Schwartz et al. (1991), were used to create a GIS layer containing drift cell locations. Important supplemental information describing some of the conditions of each drift cell is provided as a comment in the GIS and is provided on the accompanying CD. This information includes net shore drift direction and other sedimentation characteristics. WDOE emphasizes the importance of referring to and relying upon the comment information more than the strict drift cell delineations.

2.1.6 Freshwater Inputs

Information from the City of Seattle, King County, Washington Trout and WDOE was used to create the layer showing freshwater inputs to the survey area. This layer describes these locations as streams or outfalls and provides supplementary descriptive information, such as the Combined Sewer Outfall (CSO) and National Pollutant Discharge Elimination System (NPDES) status of these inputs.

2.2 Photo Interpretation

Attributes mapped by photo interpretation include the following:

- Marine riparian vegetation
- Large woody debris
- Shoreline armoring
- Impervious surfaces
- Overwater structures and marinas
- Boat ramps
- Jetties, breakwaters, and groins
- Marine rails

Photo interpretation was completed using two sources: USGS 2002 orthophotos (one foot resolution) and aerial oblique photos from WDOE. The two types of photos differed in their application to the data interpretation process, as described below. Both types of photos were often used in the interpretation, although some attributes were better interpreted by one source than the other. The orthophotos provided an aerial view looking straight down and were particularly useful for those habitat attributes that required characterizing conditions within 200 feet of the waterline. In general, the orthophotos were the primary reference for MRV distance, MRV density, jetties, breakwaters, groins, marine rails, marinas, and the extent of impervious surfaces. The cross-beach perspective provided by the aerial obliques was generally more useful for determining the extent of overhanging MRV and the locations of armoring structures. Often, due to the attribute of interest and photo quality, both types of photos were used in the interpretation. A combination was most often used for determining MRV type, LWD type and extent, and the locations and extent of boat ramps and OWS.

During photo interpretation, the line shapefile used in ShoreZone was used to visually display various conditions of the habitat attributes of interest. This line is based on the MHHW line along the survey area, but it was not always identical to the waterline at the visible break between upland and intertidal areas in the orthophotos. The two lines varied from zero to tens of feet difference in location, with a typical difference of approximately 20 feet. Consequently, the shapefile line was not used as the waterline for interpreting those attributes which considered upland conditions within 200 feet of the shoreline, namely

marine riparian vegetation and impervious surfaces. In these cases, the visible break between upland and intertidal areas was used as the waterline for interpreting these attributes. The ShoreZone line shapefile was modified to remove jetties from the shoreline configuration. Jetties extend offshore and therefore the shoreline immediately inshore is already characterized by another portion of the ShoreZone line shapefile. This modification was necessary to avoid double interpretation of the same shoreline section.

Following is a description of the types of information characterized for each attribute in the photo interpretation. All attributes were mapped to a resolution of 100 feet with the exception of shoreline armoring. That is, a discrete section of shoreline was delineated if 100 feet or more of the shoreline length had an attribute expression that was different from adjacent areas. If it was less than 100 feet, the section remained as part of the larger shoreline delineation. Shoreline armoring within the City of Seattle portion of the project area was mapped at a 50 foot resolution. More detailed information on the habitat attribute definitions and rules is provided in the data dictionary provided in Appendix A. A description of the field verification efforts is also provided below.

2.2.1   Marine Riparian Vegetation

The MRV layer was created by coding the ShoreZone line into separate sections using photo interpretation. This layer characterizes MRV within 200 feet of the water, with respect to vegetation type, distance from shore, overhang, and density (See Table 1). The vegetation types delineated were mature trees, immature trees/shrubs, grass/landscaped, and none. Vegetation type was assigned based on the dominant vegetation in the 200 foot corridor and was not necessarily the vegetation type closest to the shoreline. Vegetation was characterized as separate from the shoreline if it was separated by more than 33 feet (10 meters) from the water; otherwise, it was considered adjacent to the water. Overhanging vegetation was characterized as overhanging by 10 feet or more. Vegetation was described as continuous if the area within 200 feet of the shoreline was 75 percent or more covered by vegetation; if coverage was less than 75 percent, vegetation was considered patchy.

2.2.2   Large Woody Debris

The LWD layer was created by coding the ShoreZone line into sections in the photo interpretation process. This layer categorizes wood in the following two ways: 1) LWD coverage in areas of more than 100 lineal feet of shoreline with downed trees that appeared to still be attached at the roots and that lay across the intertidal zone and 2) drift log areas of greater than 100 lineal feet of shoreline with continuous drift logs and multiple logs stacked in the intertidal or backshore areas.

2.2.3   Shoreline Armoring

The shoreline armoring layer was created by coding the ShoreZone line by photo interpretation with field verification. The layer characterizes the presence or absence of bank armoring in a 100 linear foot resolution. Within the City of Seattle portion of the project area, armoring was mapped at a 50 foot resolution.

2.2.4   Impervious Surface Coverage

The impervious surface coverage layer was created by coding the ShoreZone line during photo interpretation and includes whether the section of shoreline exhibits high, medium, or low impervious surface coverage in the corridor within 200 feet of the waterline. Low coverage was defined as less than 10 percent coverage; medium was defined as 10 to 75 percent coverage, and high was defined as greater than 75 percent coverage. Because the 'medium' category encompasses a greater range than the other two categories, more of the shoreline falls into this category than the other two categories. Impervious surfaces included roofs of houses and buildings as well as roads, paths, and other paved areas. Lawns, open grassy areas, gravel roads/paths, and gravel parking areas were not considered impervious.

Coverage percentages were estimated by visually examining sections in the zone within 200 feet of the shoreline. In some instances, the measuring tool in ArcMap was used to measure the distance on the orthophoto covered by impervious surfaces. For example, if impervious surfaces covered 150 feet (i.e., 75 percent of 200 feet) or more, then that section and areas similar to it were coded high impervious surface; likewise, if the distance totaled between 20 and 150 feet (i.e., between 10 and 75 percent of 200 feet), then the section was coded medium impervious; and if the distance was less than 10

percent of 200 feet (20 feet), the section was coded low impervious. An example of each impervious classification is provided in Figure 2-1.

2.2.5   Overwater Structure and Marinas

The overwater structure layer was created by visually delineating OWS and marinas as polygons through photo interpretation. This layer includes piers, docks, and marinas and contains the type, compass orientation, and area for each structure identified.

2.2.6   Boat Ramps

The boat ramps layer was created by visually delineating ramps as polygons through photo interpretation. This layer contains width, length, and area calculations for each ramp identified.

2.2.7   Jetties/Breakwaters/Groins

The jetties/breakwaters/groins layer was created by visually delineating these structures as lines in the photo interpretation process. This layer includes information on the type of structure identified (jetty, breakwater, or groin) and the structure length in feet.

2.2.8   Marine Rails

The marine rails layer was created by visually delineating these structures as lines during the photo interpretation process. This layer contains information on structure length in feet.

2.2.9   Field Verification

Field verification was undertaken to gauge the quality and confidence in the efforts of photo interpretation to characterize shoreline attributes. Early in the photo interpretation effort, two representative 5-mile sections of shoreline were inventoried in the field: one along a west-facing stretch of shoreline in the vicinity of Des Moines and one along an east-facing section of the Maury Island shoreline. The field effort was conducted by boat under good weather conditions on December 8, 2003, using a differential Global Positioning System (DGPS). Field data were collected systematically for entire shoreline sections by moving along the shoreline and visually estimating where there were breaks in the classifications of riparian vegetation, LWD, shoreline

Figure 2-1   **Example of Impervious Surfaces Classification**

armoring, and impervious surfaces. More than 50 observations of classification breaks were recorded along the shoreline at each of the two sites. Each observation consisted of making a full characterization of the site for all of the habitat attributes, recording DGPS location, and noting compass bearing. In this way, a field data set of break points in classifications was created, suitable for comparison to the photo interpretation classifications.

The field verification results were compared to the preliminary photo interpretation results by considering how consistent the two methods were in assigning habitat attribute classifications and in identifying the split between two classifications (i.e., where armoring stops). Using this comparison, the level of confidence in the photo interpretation was determined based on the similarity of the results. High confidence was found in those attributes for which the results of the two methods were identical or nearly identical. Moderate confidence was found in those attributes for which the results matched frequently, but shortcomings in the photo interpretation approach were identified. As intended through the initial selection of attributes to delineate, there were no attributes that provided only low confidence results through photo interpretation. The findings for each attribute are provided in Table 2-2.

Overall, field verification efforts determined that the photo interpretation methods could be implemented successfully and provide high confidence datasets on most of the attributes of interest. The spatial data collected in the field were largely consistent with the photo interpretation results, and there was no indication of major spatial inaccuracies. Therefore, the boundaries and calculated values for the attributes delineated using these data can be referenced with high confidence. However, the field verification indicated that many of the habitat attributes characterized using photo interpretation could significantly benefit from a larger-scale field verification effort.

For attributes determined to provide only moderate confidence in the results, changes to the photo interpretation classification system were made in order to try to provide high confidence results for all parameters. After the recommended changes to photo interpretation, it was judged that the interpretation of only two parameters, MRV type and overhanging MRV, would not be able to provide high confidence results. Once field

Table 2-2
Field Verification Results

Habitat Attribute	Level of Similarity Between Initial Photo Interpretation and Field Verification Results[1]	Comments and Recommendations	Photo Interpretation Data Quality After Revising Methods to Include Recommended Changes[2]
Riparian Vegetation Type	Moderate	Photo interpretation provides a more complete look at vegetation throughout the 200 foot wide corridor back from MHHW. The field verification indicated a difficulty in determining whether the vegetation is trees or shrubs during photo interpretation. *Action:* Changed categories to: mature trees, immature trees/shrubs, grass/landscaped, other, and none.	Moderate-High
Riparian Vegetation Density	Moderate	The difference between the interpretation techniques was a consistent trend for a higher density estimate in the field than in the photo. This appeared to be due to the more complete perspective of vegetation in the 200 foot wide corridor back from MHHW that aerial photos provide. *Action:* No changes to the photo interpretation methods were warranted.	High
Overhanging Riparian Vegetation	Moderate	Photo interpretation is generally successful at identifying areas with extensive overhanging vegetation; however, sections with limited overhang into the intertidal zone are not recognizable using photos. *Action:* Changed the definition of overhanging vegetation to include only those areas that overhang the intertidal by approximately 10 feet or more.	Moderate
Riparian Vegetation Distance from Shoreline	High	Photo interpretation is very successful at identifying the distance of vegetation from the shoreline. *Action:* No changes to the photo interpretation methods were warranted.	High
Large Woody Debris	Moderate	Differences in interpretations appeared to be primarily the result of seasonal and temporal variability between the photography and field work. While in the field, the drift log category seemed overly restrictive, as many drift log accumulations were seen, but did not meet the five logs across criterion. *Action:* Changed drift log interpretation to include those areas with logs for more than 100 feet, of which at least one section has multiple logs stacked together. No other changes to the photo interpretation methods were warranted.	High

Table 2-2
Field Verification Results

Habitat Attribute	Level of Similarity Between Initial Photo Interpretation and Field Verification Results[1]	Comments and Recommendations	Photo Interpretation Data Quality After Revising Methods to Include Recommended Changes[2]
Armoring	High	The methods provided nearly identical results. There are some limitations to photo interpretation, especially in areas where armor is situated under vegetation. Another limitation of the photo interpretation is the presence of gaps between some of the aerial oblique photographs. *Action:* No changes to the photo interpretation methods were warranted.	High
Impervious Surfaces	High	Since this parameter extends to 200 feet from MHHW, photo interpretation is a better method than field interpretation because all roads, patios, etc. can be seen and measured from MHHW. *Action:* No changes to the photo interpretation methods were warranted.	High

[1] This evaluation was based on the shoreline sections interpreted prior to the field verification. The initial photo interpretation methods were revised based on the field verification results.

[2] This evaluation represents the anticipated data quality after implementing the recommendations made following the field verification.

verification recommendations were incorporated into the photo interpretation method, the entire shoreline of the project area was characterized with the new rules.

Based on photo quality, some attributes were particularly difficult to delineate along some stretches of shoreline. Best professional judgment was used to interpret the photos and the areas of difficulty were noted. Figure 2-2 shows the areas of difficulty and the attributes affected. Shoreline armoring was the most difficult attribute to evaluate due to shading across the intertidal zone and overhanging vegetation.

Figure 2-2   Areas of Difficulty in Photo Interpretation

3 RESULTS AND ANALYSIS

This section provides a general analysis of several attributes in the survey area and describes the example figures that have been provided to illustrate the attributes. Summary information for selected habitat attributes in the survey area is presented in Tables 3-1 and 3-2.

Table 3-1
WRIA 9 Habitat Attribute Analysis

Habitat Attribute	Total number of miles	Percent of Surveyed Area	Area Covered (feet^2)	Count
Lineal Shoreline Miles[1]	90.6	--	--	--
Marine Riparian Vegetation				
Trees	53.2	58.7%	--	--
Immature Trees and Shrubs	2.7	3.0%	--	--
Grass/Landscaped	25.7	28.4%	--	--
None	9.0	10.0%	--	--
Marsh Habitat[2]				
Patchy TRI	1.4	1.5%	--	--
Patchy GRA	5.4	6.0%	--	--
Patchy SAL	1.2	1.3%	--	--
Patchy SED	0.0	0.0%	--	--
Continuous TRI	0.4	0.4%	--	--
Continuous GRA	0.0	0.0%	--	--
Continuous SAL	0.5	0.6%	--	--
Continuous SED	0.0	0.0%	--	--
None	83.7	92.4%	--	--
Large Woody Debris				
Large Woody Debris	13.3	14.7%	--	--
Drift Logs	19.4	21.4%	--	--
None	57.9	63.9%	--	--
Shoreline Armoring	57.0	62.9%	--	--
Overwater Structures	--	--	5,334,771	250
Boat Ramps[3]	--	0.3%	95,349	122
Impervious Surface Coverage				
High	10.5	11.6%	--	--
Medium	43.8	48.3%	--	--
Low	36.3	40.0%	--	--

[1] Shoreline length based on ShoreZone szline shapefile used as a basemap for the photo interpretation, excluding those portions of ShoreZone units that are jetties.

[2] See Table 2-1 for descriptions of these marsh types. Percent of surveyed area calculations totaled more than 100 percent because some ShoreZone units had more than one type of marsh vegetation.

[3] Boat ramp area calculations may underestimate actual area because the submerged end of the ramps were not always clearly visible.

Table 3-2
Summary of WDNR Cross-Shore Material Information

Habitat Zone[1]	Number of miles characterized (percent of project area) [2]	Dominant Material Type[3] (percent of area characterized)	Secondary Material Type[3] (percent of area characterized))	Tertiary Material Type[3] (percent of area characterized)
Supratidal	92.8 (100.0%)	Riprap (15.5%)	Till (14.0%)	Concrete, wood (9.8%)
Intertidal	92.8 (100.0%)	Sand (36.0%)	Veneer of pebble overlying sand (10.6%)	Sand, pebble (9.3%)
Subtidal[4]	5.7 (6.2%)	Riprap (48.2%)	Riprap, wood (18.1%)	Metal (12.7%)

[1] Habitat zones defined in ShoreZone as: supratidal = above MHHW, intertidal = between MLLW and MHHW, and subtidal = below MLLW

[2] The shoreline length in the cross-shore tables was not equal to that found in other ShoreZone layers, therefore this number is not consistent with the shoreline length given in Table 3-1.

[3] Dominant, secondary, and tertiary material types based on summary of each unique material category identified in ShoreZone. For example, the material type "riprap" was distinguished from all other material types in which riprap comprised only part of the description (e.g., "riprap, concrete," "riprap, fill"). As a result, the percentages do not characterize the full extent of shoreline with riprap comprising at least part of the material combination present in the habitat zone.

[4] Characterization of subtidal zone materials was limited due to water levels and water visibility. It is unknown how representative this partial characterization is of subtidal materials in the entire project area.

Example figures are provided for selected habitat attributes of spatial information in the WRIA 9 GIS layers. Explanation of the categories shown in these figures is given in Table 2-1.

- Figure 3-1 depicts categories of cross-shore dominant supratidal and intertidal material based on the ShoreZone.

- Figure 3-2 shows marsh vegetation data from the ShoreZone. These are shoreline segments with dune grass, high marsh, and low marsh plant communities present.

- Figure 3-3 depicts shellfish information from the WDOH, including shellfish, water, and sediment sampling locations, and commercial harvest areas.

- Figure 3-4 displays wave energy and fetch in the survey area from the ShoreZone.

- Figure 3-5 depicts net shore drift in the survey area.

- Figure 3-6 gives an example of the locations of freshwater inputs to the survey area as mapped by the City of Seattle, King County, and WDOE.

- Figure 3-7 displays the categories of MRV mapped in the photo interpretation.

- Figure 3-8 is an example of shoreline segments containing drift logs and LWD mapped in the photo interpretation.

- Figure 3-9 shows sections of shoreline with and without shoreline armoring mapped in the photo interpretation.

- Figure 3-10 gives an example of impervious surface area cover as sections of shoreline mapped in the photo interpretation with high, medium, and low categories of coverage.
- Figure 3-11 depicts the lines digitized as boat ramps, marine rails, and OWS in the photo interpretation.
- Figure 3-12 displays jetties, breakwaters, and groins mapped in the photo interpretation.

Figure 3-1   ShoreZone Cross-Shore Substrate

Figure 3-2   ShoreZone Marsh Vegetation

Figure 3-3   WDOH Shellfish Data

Figure 3-4   **ShoreZone Wave Exposure and Effective Fetch**

Figure 3-5   Net Shore Drift

Figure 3-6   Freshwater Inputs (Various Data Sources)

Figure 3-7   Marine Riparian Vegetation

Figure 3-8   **Large Woody Debris and Drift Logs**

Figure 3-9   Shoreline Armor

Figure 3-10   Impervious Surface Coverage

Figure 3-11   Boat Ramps, Marine Rails, and Overwater Structures

Figure 3-12   Jetties, Breakwaters, and Groins

4 RECOMMENDED ADDITIONAL INVENTORY WORK

As indicated by the field verification effort, ground truthing of the data sets provided in this report would be very useful for evaluating data quality, particularly in areas where photo quality limited interpretation (see Figure 2-2). In addition, data for several habitat attributes would be useful for supplementing the data presented in this report. To collect this data, additional work is recommended as follows:

1. Sediment Transport Analysis – interpret current and historical photos and perform site reconnaissance with a coastal geologist to identify and characterize potential sediment sources and identify drift cell components such as feeder bluffs, contributing bluffs, transport zones, and accretion zones.

2. Substrate –
   - Collect detailed substrate information, including major breaks in substrate and dominant/subdominant percent composition (could be identified during sampling in summer low tide periods).
   - Integrate the ShoreZone substrate data and recently collected Light Detection and Ranging (LiDAR) bathymetry data to provide a more accurate characterization of substrate in lower intertidal areas and to define the spatial extent of the lower, middle, and upper intertidal zones.

3. Marsh Areas – field survey current marsh areas containing marsh vegetation, noting size and marsh type.

4. Marine Riparian Vegetation – collect information on MRV communities in the field along the shoreline to characterize seasonal overhang and potential terrestrial prey input areas; this could be characterized as coniferous vs. deciduous or by species groups.

5. Shoreline Armoring – conduct field survey during summer low tides to examine type and/or condition of shoreline armoring; possibly include characterizing stream mouth armoring.

6. Pilings – field inventory the location and number of derelict pilings and note whether they are chemically treated.

7. Seeps and freshwater inputs – collect location and size data for seeps and freshwater inputs with extensive field effort during summer low tide series.

8. Boat Ramps – use LiDAR bathymetry to determine the elevation of the outer extent of boat ramps.

5 REFERENCES

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APPENDIX A

DATA DICTIONARY

APPENDIX B

KEY SOURCES OF DATA